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JOURNAL

OF

THE ENGINEERING SOCIETY

OF

THE LEHIGH UNIVERSITY.

ISSUED QUARTERLY.

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APRIL, 1888.

JOURNAL  
OF  
THE ENGINEERING SOCIETY.  
ISSUED QUARTERLY.

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ABSTRACT OF PROCEEDINGS.

*February 14, 1888.*—A regular meeting of the Society was held at 16:15 o'clock. President Davis in the chair, and 31 members present. The committee on revision of Constitution and By-Laws submitted its report. The following papers were read: "Practical Considerations in Railroading," by Mr. Palmer, '88, and "The Manufacture of Coke," by Mr. Byers, '88. Mr. C. H. Miller explained the properties of a new explosive.

*February 28.*—President Davis in the chair at 16:20 o'clock, and 33 members present. Prof. Harding, who was present by invitation, spoke about "The Importance of the Careful Arrangement of the Outside Parts of Electric Light and Other Plants." A discussion of the proposed Constitution followed.

*March 20.*—Meeting called at 16:30 o'clock by the President. Twenty members present. Mr. Breckenridge, instructor in M.E., read a paper on "Burning Petroleum as a Fuel," chiefly the results of some experiments made by him for the B. & A. R. R., at their shops in Springfield, Mass. He furnished each member with a diagram illustrating the arrangement of the apparatus used, and exhibited a specimen burner. A vote of thanks was tendered for this paper. Mr. Beatty, '88, read a paper on "Formulæ for Weights of Bridges."

*March 27.*—Meeting called to order at 10:15 o'clock by President Davis, with 21 members present. A thorough discussion of the proposed Constitution and By-Laws was followed by a paper on "The Rotary Steam Snow Shovel," by Mr. C. H. Miller, '88.

*April 10.*—The regular meeting was called to order by Vice-President McClintic at 10:15 o'clock. Nineteen members and one visitor present. A paper entitled "Design for a Wagon Tramway with Steel Rails," by J. Hollis Wells, C.E., '85, was read by Mr. Bradford, '88. Mr. Parker, '88, read a paper on "Stand Pipes." Mr. Richards, instructor in Metallurgy, made some general remarks on "Aluminum and its Alloys." Mr. Throop, '89, read an interesting paper on "Aluminum Bronze." He exhibited a number of specimens kindly furnished by the Cowles Electric Smelting and Aluminum Co., and by Mr. Richards. Mr. Miller reported on "Bottom vs. Top Headings in Rock Tunnels." Mr. S. Yamaguchi made some remarks concerning the "Separate System of Sewerage," in Wilkes-Barre.

*April 11.*—A special meeting was called at 10:15 o'clock by Vice-President McClintic. On motion of Mr. Daniels, the following Constitution and By-Laws were unanimously adopted:

## CONSTITUTION AND BY-LAWS OF THE ENGINEERING SOCIETY OF THE LEHIGH UNIVERSITY.

### PREAMBLE.

In order to promote a beneficial intercourse among the students, Alumni, Professors and Instructors in the different Engineering Courses, and to increase our knowledge of the science by reports on Engineering investigations and publication of the same in "The Journal of the Engineering Society of the Lehigh University," the establishment of a library, the collection of models, and any other means which may be of interest to the Engineer, we, the undersigned, unite ourselves into a society, to be known as "The Engineering Society of the Lehigh University," under the following Constitution and By-Laws:

### CONSTITUTION.

#### I. OFFICERS.

The officers of the Society shall be a President, a Vice-President, a Secretary, a Treasurer and a Librarian.

#### II. ELECTION OF OFFICERS.

1. All the offices of this Society shall be filled by undergraduate members.

2. The officers shall be chosen by ballot, the majority of the votes cast constituting an election. The election to be held at the last meeting in May of each college year.

3. The duties of the officers shall begin immediately after election.

4. All offices made vacant shall be filled by special election, notice of such election having been given at a previous meeting.

### III. DUTIES OF OFFICERS.

1. The duties of the President shall be to preside at all meetings, to appoint all committees, to audit the accounts of the Treasurer, and to promote the interests of the Society. He shall call special meetings at the written request of three members.

2. The Vice-President shall perform the duties of the President in his absence.

3. The duties of the Secretary shall be to record the transactions of the meetings, to attend to all correspondence, and act as assistant to the Business Manager of the JOURNAL.

4. The duties of the Treasurer shall be to attend to all financial affairs. He shall be the Business Manager of the JOURNAL.

5. The duties of the Librarian shall be to take charge of the library, models and apparatus, and keep a correct record of the same.

### IV. MEMBERSHIP.

1. There shall be two classes of members, viz: Members and Associate Members.

2. Members shall be students in the Engineering Departments of Lehigh University after attaining their Junior year; also Professors, Instructors and Alumni in Engineering Courses.

3. Associate Members shall be students of the Lehigh University after attaining their Sophomore year. They shall be entitled to all the privileges of members, except those of voting and holding office.

### V. FUNDS.

The funds of the Society shall be used in defraying expenses incurred by the publication of the JOURNAL, and for such other purposes as the Society may direct.

### VI. REPORTS OF OFFICERS.

The President, Secretary, Treasurer and Librarian shall present written reports on the condition of their respective offices at the last meeting in May of the college year, or when called upon by vote of the Society.

## VII. PUBLICATIONS.

1. The transactions of the Society shall be published quarterly, under the name THE JOURNAL OF THE ENGINEERING SOCIETY OF THE LEHIGH UNIVERSITY.

2. The Board of Editors of this JOURNAL shall consist of the following, viz.: Two members from the Senior Class, one from the Junior Class and two Alumni members. This Board shall elect one of its members Editor-in-Chief.

3. All the Editors of this Board, except the Junior Editor, are to be chosen at the same time and in the same manner as the officers of the Society; the Junior Editor to be elected at the second meeting of each college year.

4. The subscription price of the JOURNAL shall be one dollar (\$1.00) per year.

## VIII. AMENDMENTS.

This Constitution shall not be amended except by a two-thirds ( $\frac{2}{3}$ ) vote of the resident members; the amendment to be submitted to the Society in writing at least two meetings before being acted upon.

## BY-LAWS.

## I. MEETINGS.

The time of holding all regular meetings of the Society shall be regulated by resolutions of the Society made at any regular meeting of the same, provided there be at least two meetings appointed for every month.

## II. ORDER OF EXERCISES.

The order of exercises shall be :

1. Roll Call.	6. Unfinished business.
2. Reading minutes of the previous meeting.	7. New and miscellaneous business.
3. Reports of Officers.	8. Election of officers.
• 4. Reports of special committees.	9. Adjournment.
5. Nomination and election of members.	

This order of exercises may be suspended for one meeting, by a three-fourths ( $\frac{3}{4}$ ) vote of the members present.

## III. QUORUM.

One-fourth of the resident members shall constitute a quorum.

## IV. DUES.

1. The admission fee for members shall be two dollars (\$2.00), which shall be paid within two weeks after election, and which shall entitle the member to receive the JOURNAL for two years from date of admission.

2. The admission fee for associate members shall be one dollar (\$1.00), to be paid within two weeks after election, and which shall entitle them to receive the JOURNAL one year.

## V. CANDIDATES FOR MEMBERSHIP.

The names of candidates for membership in this Society may be acted upon at the same meeting they are proposed, a majority of votes cast constituting an election.

## VI. SECTIONS.

The members of this Society shall, at the beginning of each college year, be separated into three or more sections, to be appointed by the President. The duties of each section shall be to report on different matters of interest connected with the special department assigned to it.

## VII. AMENDMENTS.

These By-Laws shall not be amended except by a majority vote of the resident members.

The proposed amendment must be submitted to the Society in writing, at least one meeting before being acted upon.

All points of order not covered by the Constitution and By-Laws, shall be decided by "Robert's Rules of Order."

C. J. PARKER,  
Secretary.

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## ON THE DIRECTION OF EARTH THRUST AGAINST A WALL.

READ BEFORE THE SOCIETY BY FRED. P. SPAULDING, INSTRUCTOR  
IN CIVIL ENGINEERING.

It is common, in discussing the thrust of earth against a wall, to consider that the thrust is due to a tendency on the part of the earth behind the wall to break off in the form of a wedge, and slide down on a certain surface, called the surface of rupture, thus forcing the wall outward. It is also common to neglect the cohesion of the earth, and consider only its frictional resistances, or to assume that the surface of rupture is a plane.

Let *A B* represent the back of a wall sustaining a bank

of earth whose surface  $B D$  is horizontal. Suppose the surface of rupture to be at  $AC$ , then the weight  $W$  of the mass of earth  $B A C$ , acting vertically through its center of gravity, is resisted by two forces, one of which  $T$ , is the reaction of the wall, and the other  $R$ , of the surface of rupture upon the wedge of earth. When equilibrium just obtains, the force  $R$  makes an angle with the normal to  $AC$  equal to the angle of friction of the material, that is, the force  $T$  is just sufficient to prevent the wedge  $B A C$  from sliding on the surface  $AC$ .

Let  $\theta$  = the angle between the horizontal and the back of the wall

$\phi$  = the angle of natural slope of the earth

$x$  = the angle between the horizontal and the surface of rupture

$d$  = the angle made by the thrust  $T$  with the normal to the wall. Now, if  $W$  be resolved into two components parallel respectively to  $R$  and  $T$  in the triangle  $b a c$ , we have

$$T = W \frac{\sin b c a}{\sin a b c}$$

or substituting values of the angles

$$T = W \frac{\sin (x - \phi)}{\sin(\theta + \phi + d - x)}$$

If  $w$  be the weight per cubic foot of the earth and  $h$  the height of the wall in feet, measured vertically,

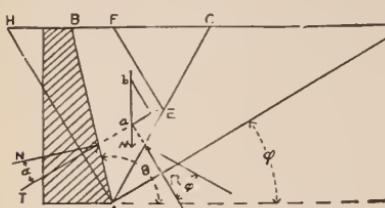
$$W = \frac{1}{2} wh^2 \frac{\sin (\delta - x)}{\sin \theta \sin x}$$

and  $T = \frac{1}{2} wh^2 \frac{\sin (x - \phi) \sin (\phi - x)}{\sin \theta \sin x \sin (\phi + \theta + d - x)}.$  (1)

As there is a tendency to slide on every plane between the natural slope and the back of the wall,  $x$  may have any value between  $\phi$  and  $\theta$ ; if  $x = \phi$ ,  $T = 0$  and if  $x = \theta$ ,  $T = 0$ . For any intermediate value of  $x$ ,  $T$  varies, and the value of  $x$  to be used in the formula is that which will make  $T$  a maximum. To find this value, we differentiate the above expression for  $T$ , and placing the first differential coefficient equal to zero, and reducing, we have,

$$\tan 2x - \tan(\theta + \phi + d)x + \frac{\sin d - \sin d \cos 2x}{2 \sin \theta, \sin \phi, \cos 2x, \cos(\theta + \phi + d)} (2)$$

from which, knowing the values of  $\theta$ ,  $\phi$  and  $d$ ,  $x$  may be found and



substituting in (1), the thrust will be determined;  $\phi$  and  $\theta$  are known quantities for any particular case, but  $d$  seems to be theoretically indeterminate, and authorities differ as to the proper manner of determining it. At the present time there are three assumptions advocated regarding it: First, Coulomb's theory assumes that the thrust is in all cases normal to the wall, making  $d = o$ , in which

$$\text{case } T = \frac{1}{2} wh^2 \frac{\sin(x - \phi) \sin(\theta - x)}{\sin \theta \sin x \sin(\theta + \phi - x)}. \quad (3)$$

$$\text{and } x = \frac{\theta + \phi}{2}. \quad (4)$$

The advocates of the use of this value do not claim that it correctly represents the direction of the thrust, but state that in view of the uncertainty existing as to its actual direction that value should be used which is most unfavorable to stability. Experiment has demonstrated quite clearly that for walls nearly vertical the thrust is not normal, and the use of this direction therefore gives an excess of stability when tested by experiment, and it has the advantage of always being on the safe side.

The second method supposes that in all cases the thrust makes an angle with the normal to the wall equal to the angle of friction of the earth upon the wall, or of the earth upon itself if that be the less value.

This theory is based upon the supposition that the wall will fail by overturning about the outside of its base, and as the back of the wall must be raised at the point of failure the friction of the earth upon the back will act to hold the wall in place. It seems probable also that, independent of any motion on the part of the wall, the action of any wedge broken off as here assumed, would be communicated to the surfaces upon which it rests in the direction of the angle of friction. This view is confirmed by the results of all experiments which have been made, and although the experiments are not conclusive, as they have not been made upon a scale of sufficient magnitude, or in an entirely satisfactory manner, still they cannot be set aside in favor of any theory which does not conform to the laws they clearly indicate.

This method is the most satisfactory, because it in no practical case gives impossible or absurd results. When the slope of the wall becomes very large, and approaches the horizontal, the condition of earth bank limited by a wall is no longer fulfilled, the case becoming that of an unlimited bank of earth, and while a perfect theory should satisfy all conditions, the failure of this method for

these cases should not be held to destroy its value for those near the vertical, where the assumed direction is known to be approximately correct.

The last method of determining  $d$  that we have to consider is that of Weyrauch. His theory, although produced in an entirely different manner, is practically the same as, or rather an extension of, that of Rankine. The method of finding the surface of rupture, although put into somewhat different shape by Prof. Weyrauch, is in reality the same as that described in the beginning of this paper, and gives the same results. In order to determine the direction of the thrust against the wall, without assuming it as in the older theories, Weyrauch determines the point of application of the force  $R$  upon the surface  $AC$  to be at one-third the height of that surface from the base of the wall. The proof of this is dependent upon the assumption that  $R$  varies as the square of the height, which can only be true provided the thrust of the wall against the earth be the same as that of an unlimited bank of earth upon a similar section; for instance, the pressure on the surface  $CE$  (see fig.) is evidently that due to the prism  $FEC$ , in which  $FE$  is a surface of rupture. Now in order that the pressures on  $AC$  and  $CE$  may be to each other as the squares of their heights, the pressure on  $AC$  must equal that due to the prism  $HAC$ , in which  $HA$  is parallel to  $FE$ . This theory seems very plausible, but in its results, it becomes apparent that there is something radically wrong with it. If  $AB$  be an imaginary section through a mass of earth, the prisms  $HAB$  and  $BAC$  will be in equilibrium, acting upon each other with two equal and opposite forces in the section. Now, if the prism  $HAB$  be removed, and the wall  $AB$  put in its place, it seems reasonable to assert that the pressure on the wall is the same as was formerly brought upon the section of earth, and it seems equally reasonable to assert that if the prism  $BAC$  be removed, and the wall put upon the other side of the section, in its place, that the same pressure will be exerted, but in an opposite direction, and yet if this be true, the pressure upon a wall leaning backward will be the same in amount as upon a wall leaning forward at the same slope, a result which is in fact obtained by the use of Weyrauch's formulae, which is manifestly incorrect, and which, as there seems to be no good reason for accepting the principle as applied to the one case, while rejecting it for the other, shows the improbability of the truth of the assumption upon which the theory rests.

For a vertical wall, this theory, like Coulomb's, gives a normal pressure, while, as already remarked, experiment seems to have fully determined that this is not its true direction; in fact, for walls as usually built, nearly vertical, the difference between the results obtained by the methods of Weyrauch and Coulomb will be very slight, and will each give excessive strength to the wall.

In this paper the case of horizontal earth surface is the only one considered, as it is at once the simplest and the one giving the widest difference between the various theories. The endeavor has been made to clearly show what the actual assumptions of Weyrauch's theory are, in order to prevent its misapprehension through the apparent statements of its exponents, that no assumptions are made in producing its formulæ, and that the difference between it and others is due to the use of the equation of moments in determining the forces for Weyrauch's method, instead of making the usual assumptions. This clearly is erroneous; the equation of moments is a convenient means of determining the forces, but it has nothing to do with the conditions of the problem, and does not replace any assumption of the old theory. The problem to be met may be briefly stated thus: Three forces meet in a point and are in equilibrium, one of them, the weight of the wedge of earth  $W$  is fully known; of the other two, the point of application of the thrust  $T$  and the direction of the reaction  $R$  are known, but the data are insufficient. One more of the conditions governing the forces must be known, before solution is possible. The old theories assume the direction of  $T$ , and Weyrauch, the point of application of  $R$ , after which the forces may be fully determined for either case, with or without the equation of moments.

It may be well at this time also to call attention to the serious errors into which a recent writer has fallen of giving directions for using Weyrauch's formulæ for determining the stability of a wall. After producing the formulæ and discussing the theory in general, he proposes that in any case where the calculated value of  $D$  is less than the angle of friction between earth and wall, to use the angle of friction instead of  $D$  for the direction of the thrust. To this, although it is quite inconsistent with Weyrauch's theory, there might be no objection, if properly done, as it would simply bring us back to the old method; but it is proposed to use Weyrauch's value of the thrust, without alteration for the new direction, which is evidently incorrect. It is again recommended to use the calculated value of  $D$ , when it is greater than the angle of

friction, although clearly such a force could not act between the earth and wall, without motion resulting, even if such a value can be obtained from the formulæ.

As already stated the actual direction of the thrust seems to be theoretically indeterminate, it being necessary for all theories to make assumptions which are more or less unsatisfactory. Weyrauch's theory, though ingenious and plausible, is unsatisfactory, and must be rejected, because it gives evidently incorrect results for many cases which properly come under it.

The final settlement of the question must then be left to experiment, and while the making of a satisfactory set of experiments is a difficult and tedious undertaking, and the theory of the subject is perhaps not of very general interest to engineers, especially as the materials upon which it is to be applied are of so variable and uncertain nature, still if a determination of this direction could be made, and a definite acquaintance with the action of the forces existing between the wall and earth could be gained, it would conduce to better engineering practice, and be of value as adding to our knowledge of the properties of the materials of engineering.

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### BURNING PETROLEUM AS A FUEL.

RESULTS OF SOME EXPERIMENTS AT THE REPAIR SHOPS OF THE  
BOSTON & ALBANY RAILROAD, SPRINGFIELD, MASS.

The following experiments were made September 6, 7, 8, 9 and 10, 1887, to see with what efficiency oil could be burned with apparatus and appliances controlled by the Aerated Fuel Co., of Springfield, Mass.:

The two boilers with which the experiments were made were rated at 80 H.P. They were of the locomotive type, well covered with wood lagging, over which was a Russia iron covering, so that the radiation was reduced as much as possible.

The two boilers were of the same dimensions, stood side by side in the same room, had a common steam pipe and were fed by one injector. One of the boilers is partly shown in Fig. 2. This boiler is supplied with two oil reservoirs, one shown at *C*, the other placed on the opposite side of the boiler is exactly similar. This reservoir *C* is supplied with a glass gauge in front, in which may be seen the height of the oil within. It is held in position by two brackets fastened to the boiler. On top may be

FIG. 1.

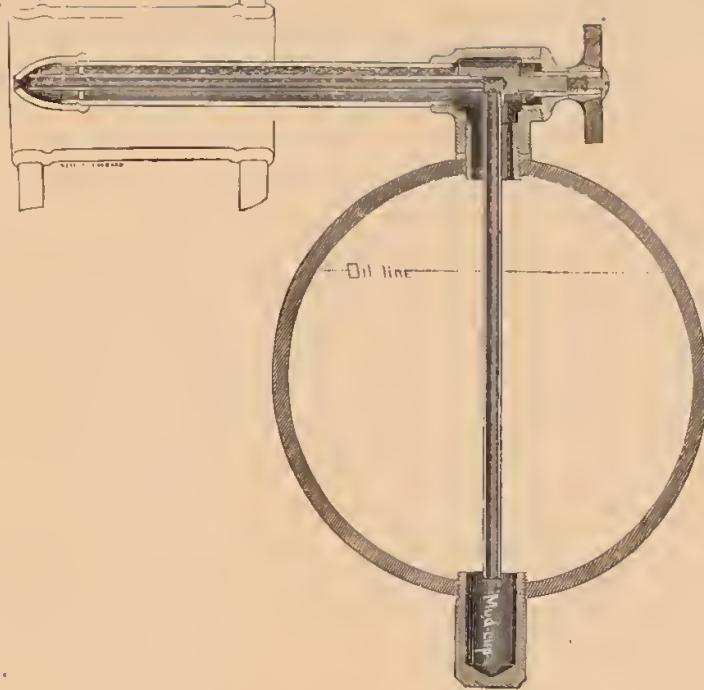
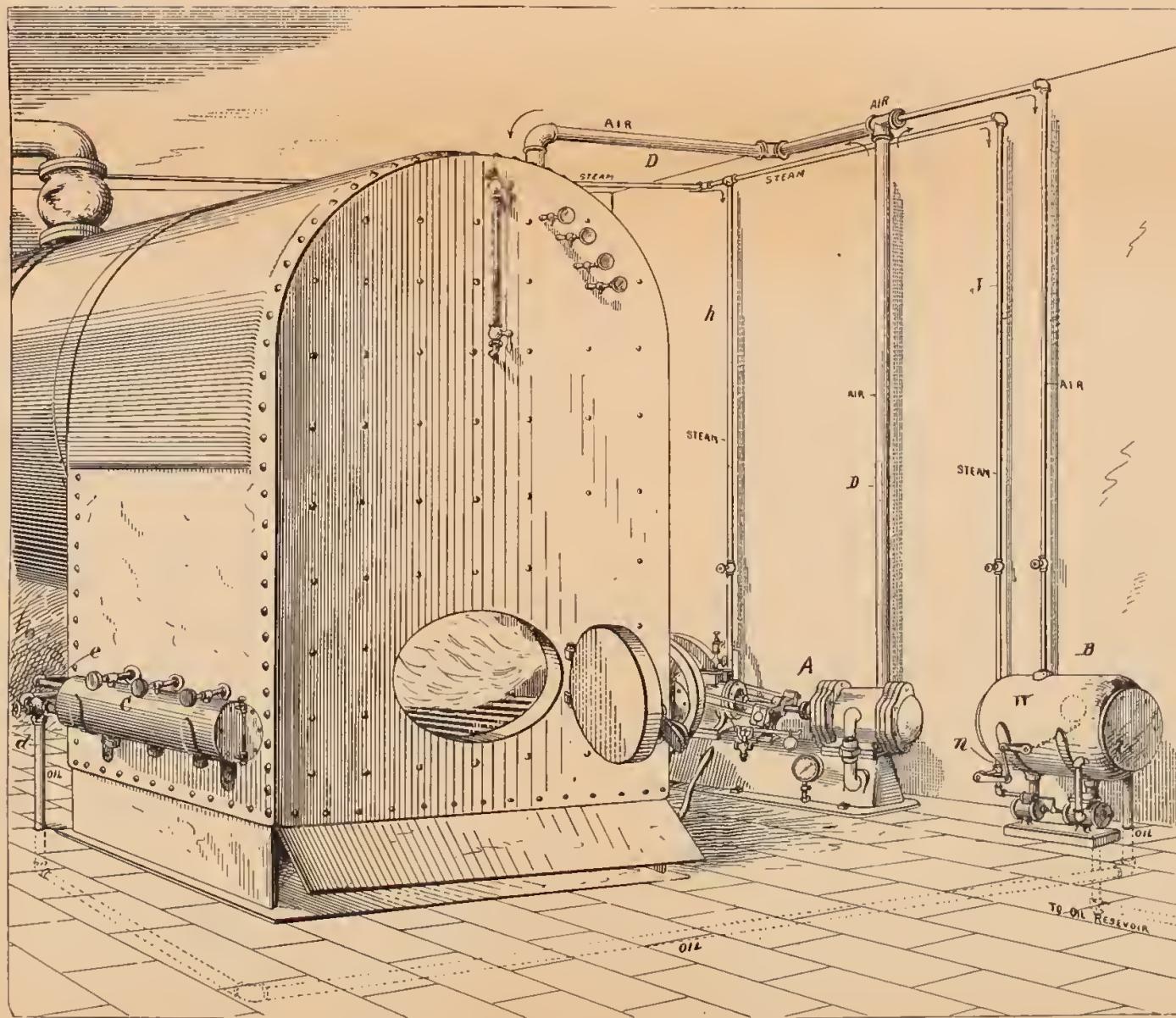
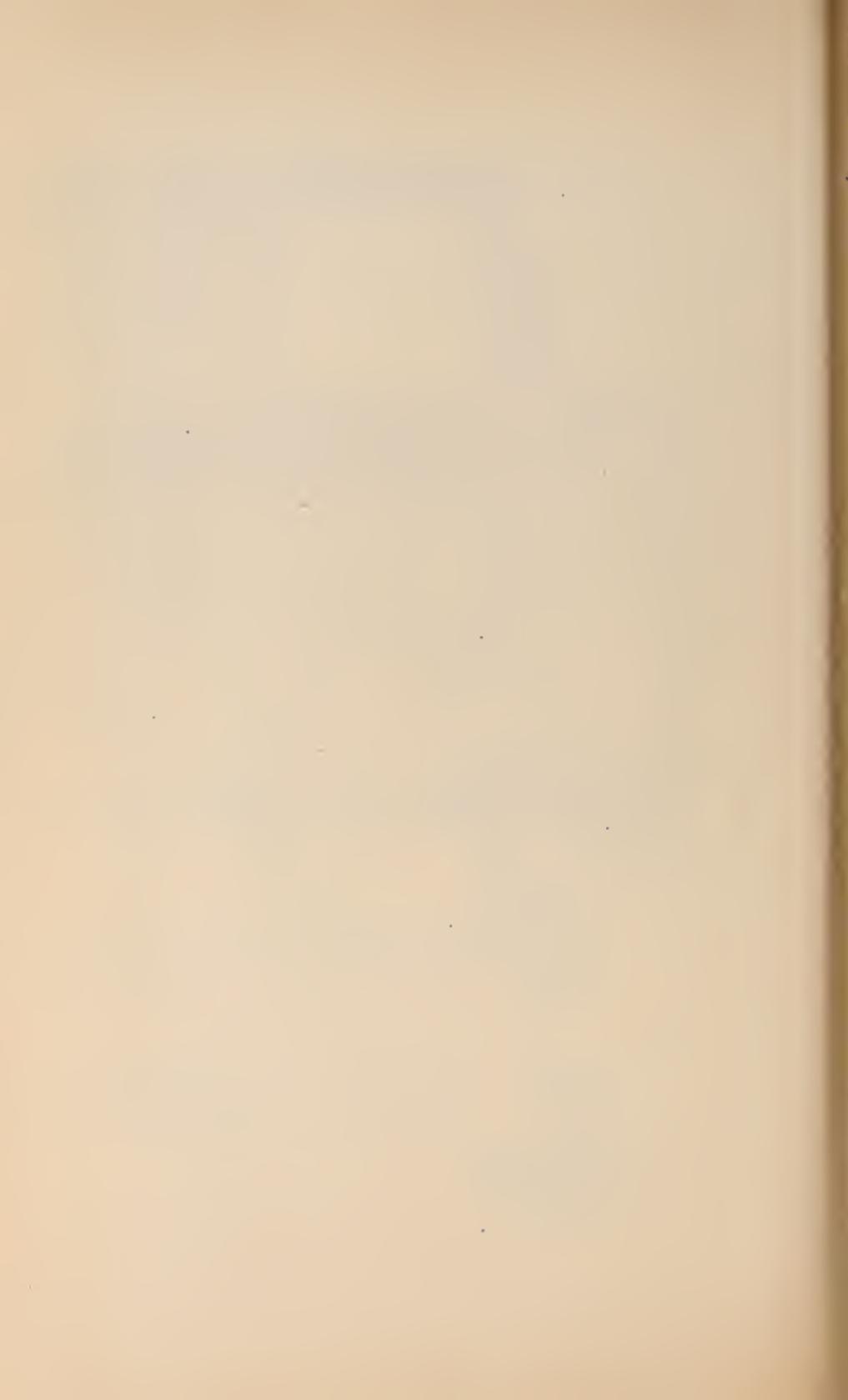


FIG. 2.





seen the three burners through which the oil flows, each burner being supplied with handles, by means of which oil may be regulated or entirely shut off.

Fig. 1 shows a cross section of this burner and also the reservoir. The oil is maintained at the level indicated in the figure by means of a simple float valve, and above the oil, under a pressure of 10 lbs., is the air which has been pumped in by the air pump at *A*. For each burner a hole is made through the side of the boiler; nearly through this the burner extends, while around the burner part of the air necessary for combustion may enter.

An examination of Fig. 1 will show that the oil to be burned is forced through the small ( $\frac{3}{16}$ ") pipe inside, while the air which serves to spray the oil passes along the larger ( $\frac{3}{4}$ ") outside tube.

The regulation is effected by changing the position of the inside tube. When this tube is advanced so as to be in contact with the outside nozzle at the end, no air can pass out, but a solid stream of oil would flow. If, on the other hand, this inside tube recedes from the end of the nozzle say  $\frac{3}{8}$  of an inch (which is about its limit), then the pressure of air being the same at both ends of the tube no oil will flow, but air only will be blown through the nozzle. The diameter of the hole in the end of the nozzle was  $\frac{1}{16}$ " diam.

As to the means adopted for keeping the side reservoirs supplied with oil, it may be said that if the position of the boiler is such that these reservoirs are about 30 feet below the storage tank the oil will flow in by the action of gravity. If not so situated, it may be pumped in by the automatic device shown in Fig. 2 at *B*. This is simply a small steam pump operated by steam from the boiler through the pipe *J*. This tank *B* is set level with the two side reservoirs and the float shown within in dotted lines is so connected to the valve at *N*, in the steam pipe *J*, that the height of the oil in all the tanks will be the same. The suction pipe of the pump is, of course, connected with the storage tank or car, as the case may be.

In the figure *A* is an air pump for supplying air to the top of side reservoirs; a small pipe connects with *B* in order that the pressure on all the oil may be the same.

In the tests under consideration the air was supplied to the side reservoirs by an air pump, the same as used to pump air for the Westinghouse air brakes. Size of the air cylinder being 8" diam., stroke 8". All the water fed to the boilers during these

tests was carefully weighed in uniform amounts of 400 lbs. All the oil burned was also weighed, the suction pipe from the oil pump being carried to a barrel placed on scales for this purpose.

In the smoke box of each boiler, in the same place as nearly as possible, was inserted a piece of  $1\frac{1}{4}$ " gas pipe closed at the lower end and filled with cylinder oil. In this oil was placed a thermometer, from which readings were taken and recorded as the "Temperature of escaping gasses."

The steam for running the air pump was taken from the boilers, and in order that the amount of steam used to furnish the necessary air for spraying the oil might be known, the exhaust steam from the pump was all condensed and the condensed water weighed.

The boiler tubes were cleaned a few days before the tests began and were in fair condition during all the trials. New tubes were put in the boilers about six years ago, and the results of the trial with coal indicate that the internal condition of the boilers was good.

The observations made during the tests, burning oil, were at intervals of 20 minutes and were as follows:

1. Height of oil in the main oil tank.
2. Height of water on glass gauge of boiler No. 1.
3. " " " " " No. 2.
4. Steam pressure in pounds per sq. inch (gauge).
5. Air pressure on the oil in pounds per sq. inch (gauge).
6. Temperature of the boiler room.
7. Temperature of escaping gasses.
8. Temperature of steam condensed from air pump.
9. Weight of steam condensed from air pump.
10. Force of draught in inches of water.
11. Strokes of air pump per minute.
12. The weight of oil pumped into main oil tank.

The height of the oil in the four small reservoirs, the height in the main oil tank, the height of the water in the boilers, as well as in the feed water tank, were all brought to the same level at the end as at the beginning of an experiment. An effort was also made to have the same steam pressures at the beginning and end of a run, and when such a result did not obtain the proper correction was made for it.

Similar observations were taken while burning coal and the same scales used to weigh the coal as the oil. The coal delivered

to each boiler was not kept separate, but the ashes from each were weighed separately and found to be the same., i.e., 133 lbs. and 127 lbs.

The feed water was all weighed in uniform amount of 400 lbs. at a time and the temperature taken once in about 20 minutes.

The barometer readings taken at the Springfield Armory on the several days of the tests were the ones used and recorded in this report.

The coal used was a good quality of bituminous. It was kept in the yard, not under cover, was brought in as needed, weighed and dumped on the floor in front of the boilers. A sample of 100 lbs. taken from the same place as that used was carefully weighed, afterward weighed again to see if any moisture was contained in it. After drying five hours it still weighed 100 lbs., and was, as it appeared, quite dry.

#### ANALYSIS OF THE OIL.

The oil used was from Lima, Ohio; it was carefully analyzed by Chas. Mayr, of Springfield, and the following is copied from his report:

"By ultimate organic analysis, the oil was found to consist of

Hydrogen,	17.10%
Carbon,	80.20%
Oxygen Impurities,	2.70%
<hr/>	
100.00	

The specific gravity of the oil at 75° is .831.

One cubic foot weighs 51 lbs. 14 oz.

One gallon weighs 6½ lbs., very nearly.

Its theoretical heating capacity per pound is 18,450.2 (pounds of water × deg. Fahr.) heat units.

Pounds of water evaporated in open vessel by 1 lb. of oil, water boiling at starting:

Theoretical combustion with pure oxygen, . . . . .	19.27 lbs.
Best practical combustion with air, . . . . .	18.07 "
Good practical combustion with excellent precautions,	14.34 "

It will be seen by referring to table I, that in the tests during the nine hours' run, the evaporation at and from 212°F., which corresponds to the above conditions in the oil analysis, was 15.40 lbs. water per pound of oil.

Comparing this with the theoretical combustion with pure oxygen, we see that the apparatus so handled the oil that it burned with an efficiency of 79.93 per cent., or an efficiency of

$\frac{15.40 \times 100}{18.07} = 85.22\%$  compared with best practical results with pure air.

Table 1. is a condensed summary of four runs with oil and one with coal.

Before making the 9-hour test with the oil, several tests were made to determine the most economical pressure to carry on the air for spraying. This was found to be very nearly 10 lbs. per sq. inch. Below 7 lbs. steam could not be kept up to the desired pressure, which above 14 it was necessary to shut off one burner on each boiler occasionally, while the steam used by the air pump increased without an increased evaporation in the boiler.

Table 11. is the detailed record of the two 9-hour runs with coal and with oil giving proportions of boiler and so forth.

No change was made in the boiler for these two tests except to stop up the holes the burners were placed in, while coal was being burned.

While burning coal there was a damper regulator attached to the boiler, which held the steam constantly at one pressure. A similar attachment for regulating the flow of oil through the burners by the steam pressure will be found useful and beneficial.

The means employed for condensing the exhaust steam from the air pump was by taking a 36" six-column Union radiator, inverting it in a barrel of running water and connecting the exhaust pipe from the pump directly with the top sticking out of the barrel and a pipe leading from the bottom of the side of the barrel discharged the condensed steam, which was caught and weighed.

Within the furnace there was nothing placed, as firebrick is often used when burning oil, to prevent injury to the plates, but instead, the burners were placed directly opposite each other, so that one flame coming against the opposite one, the resulting flame was much spread out and prevented from doing injury to the plates.

These two boilers were run by oil for the greater part of the Summer and the sides of the furnace and crown sheet showed no signs of burning.

TABLE I.—CONDENSED TABLE OF COAL AND OIL TESTS.

	Sept. 7. Oil 9 hrs.	Sept. 6. Oil, 2 hrs. 30 m.	Sept. 6. Oil, 5 hrs.	Sept. 9. Oil, 5 lbs. ton.	Sept. 8. Coal, 9 hrs.
1. Date of Tests, 1887.....					
2. Kind of Fuel.....					
3. Duration of Test.....					
4. Consumption of oil, total in pounds.....	1676	455	930	1038	250
5. " " per hour in pounds.....	186.22	182.0	186.0	201.0	250
6. Average temperature of feed water.....	68.	68.5	68.0	65.5	67.
7. Boiler pressure in pounds by gauge.....					
8. Total water evaporated, actual conditions, lbs.....	63.86	64.67	62.44	64.50	66.90
9. " " " per hour.....	2182.9	599.0	171.6	1302.6	2030.7
10. Water evaporated by 1lb. oil .....	2425.6	2396.0	2343.2	2522.5	2256.3
11. " " at and from 212° F .....	13.02	13.16	12.60	12.55	9.93
12. Average air pressure on oil in lbs., (by gauge).....	15.40	15.54	{ 12.55 3 hrs.	14.85	10.68
13. Steam used per hour by air pump, pounds.....	9.35	9.34	{ 7.88 2 "	13.6	
14. Total steam used by .....	157.3	157.3	{ 18.96 3 hrs.	200.41	
15. Per cent. of steam generated used by air pump.....	1415.7	393.2	{ 14.2 2 "		
16. Strokes of air pump, per minute (double).....	6,38 p.c.	6,56 p.c.	853.38	1035.4	8.00 p.c.
17. Temperature of escaping gases, No. 1 Boiler.....	36.5	36.5	44—3 hrs.	7.28 p.c.	
18. " " " 2 "	332°	—	33—2 "	46.5	
19. " " of steam in boilers.....	30.0	—	387° 3 hrs.		
20. Water evap. per sq. ft. of heating surface, per hour.....	312°	—	325° 2 "		
21. Consumpt. of oil per sq. ft. of grate .....	.97	.958	309.7°	311.5	285.7°
	8.86	8.86	.937	311.0	269.1
			8.86	313.5	313.5
				9.02	9.02
				1.01	
				9.60	
					tr. 9

## COST AND EFFICIENCY OF EACH FUEL.

## COAL. OIL.

1. Pounds of water evaporated at and from 212° per pound of fuel.....	10.68	15.54
2. Price paid for fuel per ton (2000 lbs.) and per bbl.....	\$4.50 ton	\$1.16 bbl.
3. No. of pounds, costing \$1.00.....	444.4 lbs.	236.3 lbs.
4. British Thermal Units (B.T.U.) contained in each pound of fuel.....	14,800	18,450
5. B.T.U. transferred to water in boiler per lb. of fuel.....	10.317	15.012
6. Per cent. of heat in fuel transferred to water in boiler.....	69.7 p. c.	78.7 p. c.
7. B.T.U. which can be bought for \$1.00.....	6,577.120	4,359,735
8. B.T.U., costing \$1.00, which may be transferred to water in the boiler.....	4,580.748	3,542,832
9. Price of same number of B.T.U. delivered to water in boiler by each fuel.....	\$ .77	\$1.00

A weight of 7.3 lbs. per gallon would correspond closely to many of the grades of petroleum; also, 20,000 heat units per pound is not an uncommon value for the theoretical number of heat units contained in a pound of the fuel.

In order to derive approximate formula representing the cost of petroleum and coal let us make the following assumptions:

42 Gallons oil,                            1 barrel.

1 Gallon oil weighs                      7.3 lbs.

1 Pound oil contains 20,000 heat units.

1 Pound coal contains 12,000         "

Per cent of heat in coal transferable to water 70 per cent.

"       "       "       oil       "       "       80       "

We shall have then

$$\frac{70 \times 12,000}{100} : \frac{80 \times 20,000}{100} :: 1 : 1.91$$

$$\text{or } 1 \text{ lb. oil} = 1.9 \text{ lbs. coal.}$$

$$.5263 \text{ lbs. oil} = 1 \text{ lb. coal.}$$

$$1052.6 \text{ lbs. oil} = 2000 \text{ lbs. coal.}$$

But 1 bbl. oil weighs  $42 \times 7.3 = 307$  lbs., therefore

$$\frac{1052.6}{307} = 3.44 \text{ bbl.} = 2000 \text{ lbs. coal.}$$

If then we let  $C$  = price per barrel of oil and let  $T$  = price per ton of coal, we shall have under the above conditions,

When  $3.44 C = T$  coal or oil may be burned with equal cheapness.

When  $3.44 C > T$  it is cheaper to burn coal.

When  $3.44 C < T$  it is cheaper to burn oil. From this formula the following table is made, showing at what prices coal or oil might be used as a fuel under steam boilers at the same cost of fuel.

PRICE OF OIL PER BARREL.	PRICE OF COAL PER TON, TO BE AS CHEAP AS OIL.
\$ .40	\$1.38
.50	1.72
.60	2.06
.70	2.40
.80	2.75
.90	3.10
1.00	3.44
1.10	3.78
1.20	4.13
1.30	4.47
1.40	4.82
1.50	5.16

The use of petroleum for fuel in forges or furnaces where the character of the product is improved or the product itself increased is where it can compete much more successfully with coal. The Franklin Moore Co., Winsted, Ct., writes as follows concerning this subject: "We find that a barrel of crude oil will run a forge fire for 7 days, that has used 120 lbs. of coal per day upon the average. But, even if it cost more than coal, we should feel constrained to use it, because it is such an even fire all the while, needs no attention, makes no ashes and gives us full value for every cent we pay for fuel.

Cost of coal 7 days, \$2.73.

Cost of oil 7 " 1.22."

At Woolwich, England, in the manufacture of armor plate for war vessels, most remarkable results have been obtained by the use of liquid fuel. Under ordinary circumstances, the armor plate bending furnace is lighted from 4 to 5 hours before the plate is placed in it. The time occupied in heating the plate for bending depends upon the thickness—1 inch per hour being allowed. So that from 10 to 11 hours elapse from the time of lighting the fires before the plate is ready for bending. With liquid fuel the time is  $2\frac{1}{2}$  hours for the same work performed. With the liquid fuel the plates are free from scale, a source of considerable loss when coal furnaces are used—6 jets are sufficient for a plate 6 inches thick, 7 feet 6 inches long and 3 feet wide.

#### RESULTS OF TWO TRIALS OF TWO BOILERS OF THE LOCOMOTIVE TYPE—BURNING OIL AND COAL.

#### TO DETERMINE THE EVAPORATIVE EFFICIENCY UNDER THE DIFFERENT CONDITIONS.

ITEMS.	BURNING COAL	BURNING OIL
1. Date of trial.....	Sept. 8, 1887.	Sept. 7, 1887.
2. Duration of trial.....	9 hours	9 hours.
DESCRIPTION AND PROPORTIONS.		
(a) Type of boiler.....	Locomotive.	
(b) Diameter of shell.....	50 inches.	
(c) Length of shell.....	19 ft.	
(d) Number of tubes. { Vertical.....		
	139	
(e) Diameter of tubes.....	2 $\frac{1}{4}$ in.	
(f) Length of tubes. { Vertical.....		
	15 ft. 8 $\frac{1}{2}$ in.	
(g) Diameter, steam drum.....		
(h) Length of furnace.....	42 in.	
(i) Width of furnace.....	37 "	
(j) Kind of grate bars.....	plain.	
(k) Width of air spaces .....	$\frac{3}{4}$ inch.	
(l) Ratio of area of grate to area of air spaces.....	2.42 to 1	
(m) Area of chimney .....	1.4 sq. ft.	
(n) Height of chimney above grate.....	39 ft.	
(o) Length of flues connecting to chimney.....	--	
(p) Area of flues connecting to chimney.....	--	

Same Dimensions here as for coal.

ITEMS.	BURNING COAL	BURNING OIL.
GOVERNING PROPORTIONS.		
(a') Grate surface.....	10.5 sq. ft. 1259	
(b') Heating surface { Steam .....	1259 sq. ft. " 3.2 "	
} Total.....	1 to 120. 1 to 3.28	
(c') Area of draught through or between tubes.....	1 to 393.	
(d') Ratio of grate to heating surface.....	10.5 sq. ft. 1259	
(e') Ratio draught area to grate.....	" none	
(f') Ratio draught area to total heating surface.....	120 to 1	
3. Grate surface, wide 37 in.; long 42 in.; area 105 square ft.....		
4. Water heating surface.....		
5. Superheating surface.....		
6. Ratio of water heating surface to grate surface.....		Same Dimensions here as for Coal.
AVERAGE PRESSURE.		
7. Steam pressure in boiler by gauge.....	66.9	63.86
8. Absolute steam pressure.....	81.39	78.21
9. Atmospheric pressure per barometer.....	14.49	14.35
10. Force of draught in inches of water.....	0.125 in.	0.125 to .2
AVERAGE TEMPERATURE, FAHR.		
11. Of external air.....	66.2	71.0
12. Of fire room.....	81.0	91.8
13. Of steam.....	313.05	310.29
14. Of escaping gases.....		
15. Of feed water.....	67	68
FUEL.		
16. Total amount coal consumed (includes wood X 0.4).....	2250 lbs.	1676
17. Moisture in coal.....	none.	
18. Dry coal consumed.....	2250	
19. Total refuse dry; pounds = .....		
20. Total combustible (item 18 less item 19).....	253 lbs = 11.23 pc	none.
21. Dry coal consumed per hour.....	1997	1676
22. Combustible consumed per hour.....	250	
	221.9	186.22
RESULTS OF CALORIMETRIC TESTS.		
23. Quality of steam (dry steam taken as unity).....		
24. Percentage of moisture in steam.....		
25. Number of degrees superheated.....		
WATER.		
26. Total wgt. of water pumped into boiler and apparently evaporated.....	20,307 lbs.	21,829 lbs.
27. Water actually evaporated corrected for quality of steam.....	20,307 "	21,829 "
28. Equivalent water evaporated into dry steam from and at 212° F.....	23,984.6 lbs.	25,780
29. " total heat derived from fuel in British thermal units.....	23,169,123.6	24,942,704.0
30. " water evap. into dry steam from and at 212° F. pr. hour	2665	2864.4
ECONOMIC EVAPORATION.		
31. Water actually evaporated per pound of dry coal from actual pressure and temperature.....	9.03	13.02
32. Equivalent water evap. per lb. of dry coal from and at 212° F...	10.68	15.40
33. " " " of combustible " " " F...	12.03	15.40
COMMERCIAL EVAPORATION.		
34. Equivalent water evaporated per lb. of dry coal with one-sixth refuse at 70 lb. gauge pressure from temperature of 100° F. (= item 33 X 0.7249) .....	8.72	
RATE OF COMBUSTION.		
35. Dry coal actually burned per sq. ft. of grate surface per hour.....	11.90	
36. { Consumption of dry coal { Per sq. ft. of grate surface.....	12.68	8.86
37. { per hour, coal assumed { " " water heating surface...	0.106	0.74
38. { with one-sixth refuse, " " least area for draught...	95.07	66.40
RATE OF EVAPORATION.		
39. Water evap. from and at 212° F. per sq. foot of heating surface per hour.....	1.06	1.14
40. { Water evap. per hr. from { Per sq. ft. of grate surface.....	110.38	118.64
41. { temp. of 100° F. int. to steam { " " water heating surface...	0.92	0.99
42. { of 70 lbs. gauge pressure. " " least area for draught...	827.8	889.6
COMMERCIAL HORSE-POWER.		
43. On a basis of 30 lbs. water per hour evap. from a temp. of 100° F. into steam of 70 lbs. gauge pressure, 34½ lbs. from and at 212° F.	77.25	83.07
44. Horse-power, builders rating at 15 square feet per H. P. ....	167.87	167.87
45. Per cent. developed below rating.....	54 per cent.	50.54 per cent.

### THE ROTARY STEAM SNOW SHOVEL.

The want of a more efficient and less expensive method of removing deep snows from railroad tracks, especially those of the Western roads, led to the invention of the Rotary Snow Plow. It was invented by Orange Judd, of Orangeville, Canada, and was patented Jan. 15, 1884. It was first tried in the yards of the

Canadian Pacific Railway at Toronto, April 1, 1884. We therefore see that it is a comparatively new machine; yet it has been tried very extensively, and with marked success.

It works somewhat on the principle of an immense auger in its manner of boring into a drift; but instead of pushing the borings behind, it throws them to one side. It consists of a heavy wrought-iron frame made of 12-inch I beams, carrying on its front end a steel drum nine feet in diameter, with a square front ten feet wide; in this drum are twelve rotating shovels made of steel and arranged like a fan wheel. In front of the shovels are four reversible steel knives. On the rear end of the frame are the engines and boiler which give the power to rotate the fan and the knives. The whole is mounted on two heavy four-wheeled trucks.

The knives are of half-inch plate, forty inches long and twenty-four inches wide, and swing on fixed arms; they have two edges, and are reversed when it is desired to run the shaft in the opposite direction; these fixed arms are placed slightly in front of the drum face proper, so that when the knives are in position they stand out at an angle of about thirty degrees with the face. The spaces between the knives are closed with steel plates five-sixteenths of an inch thick in the form of sectors; these form the face of the drum. The width of the openings between these plates and the edges of the knives is about twelve inches. The casing projecting in front of the knives slopes outward at the sides and at the top and bottom, so that the latter are fed from the sides of the cut, leaving a clear path for the machine behind.

The knife wheel is carried by a solid shaft; and the shovels, behind the knife wheel, by a hollow shaft revolving around the solid one. The knives revolve at a rate of speed varying from two hundred to three hundred revolutions per minute. The shovels revolve at the same rate of speed, but in an opposite direction. They have double the capacity of the knives in order to guard against choking.

The snow is forced by the knives into the shovels, when the centrifugal force causes it to move toward the outer ends of the shovels. They are closely boxed in, with the exception of an opening at the top, through which the snow is thrown. The opening is formed by the sides of the drum leading off tangentially at an angle of about fifty degrees with each other. These are cut off at the top, leaving an open space of about forty inches measured horizontally. This opening is so arranged by means

of a hinged plate, that when the fan is reversed it can be adjusted to throw the snow to the other side. When the fan is going at two hundred revolutions per minute, we find that the velocity at the circumference exceeds sixty miles per hour. This fully accounts for the distance to which it throws the snow in some cases. For example: at Buffalo, in March, 1885, one of these shovels was tried on a track covered with snow and ice from two to six feet in depth, which had lain all Winter, and it threw it over a trestle thirty-two feet high, and to a distance of from one hundred to three hundred feet from the track.

The knife wheel and shovels are driven by two engines, having their boiler and everything complete on the rear end of the car. The two main gear wheels are of cast steel and weigh one thousand pounds each. These engines are not used to give motive power to the plow; this must be obtained from an ordinary locomotive, which pushes the plow against the snow. The engines and boiler are boxed in to protect them from snow, the whole very much resembling a huge box-car. It is 42 feet 2 inches long, 10 feet wide, and 12 feet 8 inches to the top of the spout. The whole machine weighs about 45 tons.

The speed of the knife wheel was found to be unnecessarily high, and in the later machines it is reduced. The knife blades, which previously were mounted upon a separate shaft, are now placed upon the same shaft with the fan, and hence revolve in the same direction as the fan; also, the knives have been made to reverse automatically.

In order to secure a clean rail a flanger is placed behind the back wheels of the forward truck; it clears the snow one and a half inches below the rail head and to a distance of six inches inward; it can be raised and lowered for crossings and frogs; in case that this is forgotten, a safety bolt will break when it strikes an obstruction, thus preventing the more complicated parts from being broken. When the track is covered with ice the plow is provided with an ice breaker which can be lowered in front of the forward truck, and which works very much like a flanger.

The cost of running this shovel is a great saving over that of the ordinary snow plows and army of men which heretofore have had to be depended upon, and which, in case of severe storms, have in so many instances resulted in serious loss through wrecking of engines and loss of traffic in consequence of heavy snow blockades. These need never occur when the rotary is used.

The following is a table giving the expenses of running this shovel for one month, taken from the Union Pacific Railway Co.'s official report:

## Rotary—

Engineer and firemen's wages,	. . . . .	\$270.00
Fuel, 58 tons,	. . . . .	116.00
Oil, tallow and waste,	. . . . .	36.50
Material,	. . . . .	70.00
		—————\$492.50

## Pusher—

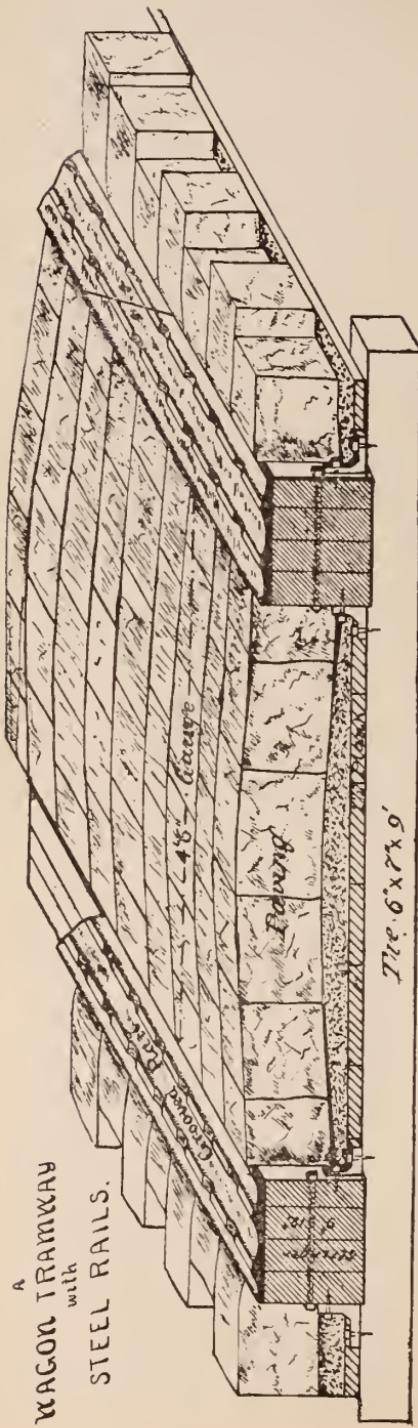
Engineer and firemen's wages,	. . . . .	\$184.00
Fuel, 111 tons,	. . . . .	222.00
Oil, tallow and waste,	. . . . .	10.80
Material,	. . . . .	7.80
Labor,	. . . . .	65.50
		—————\$490.10
Total,	. . . . .	\$982.60
Miles run by shovel,	. . . . .	2930.2
Cost per mile,	. . . . .	\$0 168
Cost per mile, including Pusher.	. . . . .	0.335

From another report I find that it cleared 3,228 miles of track in 206 hours, or an average of 15.6 miles per hour. This time includes the time lost in clearing side tracks at different stations, making the average running time about 20 miles per hour. The depth of snow in the above account ranged from 3 feet to 12 feet, and in some instances, up to 16 feet. A telegram from Minneapolis says that 300 miles 15 feet deep were cleared in 16 hours.

The right to build these plows in this country was purchased in 1884, by the Rotary Steam Snow Shovel Manufacturing Co. of Paterson, N. J. During the last Winter they built no less than ten of these shovels for the various Western roads. The price of these machines at the present time is \$15,000 each. The loss to a road not using one of these plows is frequently many times this amount, in a single Winter; besides the loss of many lives.

CHAS. H. MILLER.

## DESIGN FOR A WAGON TRAMWAY WITH STEEL RAILS.



The idea of laying tramways as a means of facilitating traffic and lessening the wear and tear of street pavements in cities is a very old one in Europe, but we in this country have not as yet dealt with the matter as it deserves. The practice in Italy was to lay parallel lines of stone blocks several feet apart. These blocks were each about four feet in length and wide enough to allow the wheels of wagons to travel along them. In the city of London "tram-blocks" are still laid in places subject to very heavy traffic.

A most important branch of engineering at the present day relates to street pavements. Two most important elements in a street pavement are durability and smoothness, and with the materials used we are never fully able to combine them. A pavement of granite blocks laid on a foundation of concrete, with joints caulked with gravel and tar, is undoubtedly the best of modern street pavements, but even this is rapidly pounded out of shape. As a rule the better the pavement the heavier the traffic. Recently, Fifth Avenue in New York City was paved

at a cost of half a million dollars. The traffic on that avenue has quadrupled since then, and in three years' time, unless the proper steps are taken, this pavement will be as bad as the original was.

The plan presented by Gen. Roy Stone, formerly engineer in charge of the Fifth Avenue repairing, for relieving this traffic, is one which commends itself on account of the great durability of the structure and the simplicity of its construction. He proposes to lay tramways of steel rails on two or three of the avenues parallel to Fifth Avenue. The general construction of this tramway is very similar to that of the ordinary street railway, except that a flooring of plank is laid on the ties, so that it is not necessary to disturb the structure in order to get at sewer, gas or water pipes. On this flooring is placed a layer of sand several inches in depth on which are paved granite or wooden blocks, and all joints are thoroughly caulked with gravel and tar, so as to render the pavement perfectly water-tight. The rails are grooved, both transversely and longitudinally, and the ends are mitered and meet on a plate so constructed as to form a slip-joint. The rail being thus continuous, and a truck adapting itself to whichever longitudinal grooves that meet the gauge of the wheels, the draft is very much lightened and greater speed is obtained. As two tramways are laid on a street, one for the up-going and the other for the down-going traffic, there is little liability to a blockage. By proper construction of the rails it is an easy matter, too, for a truck to turn out of the tramway into a side street, and, in fact, there has not been a single detail that has been overlooked. It is probable that a thousand feet of tramway will first be laid in New York as an experiment. Should it prove a success, as it undoubtedly will, it will, in the course of a few years, come into general use in all large cities.

JAS. HOLLIS WELLS, C.E.

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#### STAND-PIPES.

In connection with systems of water supply, particularly those of small towns, the metallic stand-pipe is of great value. It not only provides for fluctuation in the consumption, but allows the pumping engines to work at uniform speed and uniform pressure, the most advantageous conditions in every way.

The best form for a stand-pipe is cylindrical, as it is best adapted

to resist internal pressure, presents the least resistance to wind pressure, and reduces the amount of material to a minimum.

Exposed stand-pipes are subjected to enormous strains due to wind pressure, which must be considered in proportioning the thickness of metal, size of anchor bolts, weight of anchorage, etc. Although very little is known concerning the relation of velocity to the pressure of wind upon an object placed at right angles to its direction, it is generally assumed to vary as the square of its velocity, or

$$p = \frac{v^2}{200}, \quad \text{where } p = \text{pressure in lbs. per square foot.}$$

$$v = \text{velocity of wind in miles per hour.}$$

It has been stated by Gen. Hazen that "the above relation is the most satisfactory yet determined, and does not differ more than 4 or 5 per cent. from the truth."

To determine the moments due to wind, a maximum pressure of 40 lbs. per square foot on a surface normal to the direction of the wind should be used, according to the best engineering practice.

The wind pressure on the curved surface of one semi-circumference of a vertical cylindrical tank is very nearly 0.5 that upon its vertical projection. The centre of pressure and resultant, for the purpose of computation, may be considered as acting at the centre of gravity of the vertical diametrical plane, which in the plain tank of equal diameter throughout its height is at the centre of height  $= \frac{1}{2} h$ .

The most unfavorable condition to stability occurs when the tank is empty, hence to resist overturning the following condition must be satisfied, viz.:

$$IV > 0.5 h^2 P,$$

in which,

$W$  = weight of tank (when empty) in lbs.

$h$  = height of tank, in feet.

$P$  = the maximum wind pressure, in lbs. per square foot.

If the above condition is not satisfied the tank must be anchored in position.

For stand-pipes of great height, the resultant would not be at  $\frac{1}{2} h$ , as the few experiments that have been made show that the velocity of wind, and hence the pressure, is different for different elevations above the surface and increases with the height.

From the report of the U. S. Signal Service, we find that the curves traced out by variations of velocity from 15 feet to 50 feet

above the surface, coincide most nearly with parabolas, having their vertices in a horizontal line 72 feet below the surface, and that the parameters of these parabolas increase directly in the ratio of the squares of the velocities of the different gales.

The thickness of metal to resist internal pressure varies with the proportions of the stand-pipe and quality of material, and may be determined by the following formula :

$$t = \frac{\rho r f}{S} = \frac{2.604 d h}{S} f, \text{ since } \rho = .434 h. \quad (B)$$

in which,

$t$  = thickness of the metal sheet, in inches.

$d$  = diameter of tank, in feet.

$S$  = ultimate tensile strength of metal, in lbs. per square inch.

$h$  = depth from the surface of water, in feet.

$f$  = factor of safety used.

For stand-pipes of large diameter and in exposed positions, the factor of safety,  $f$ , should be greater than for small diameters and protected positions; it should also increase with the depth, as the risk of rupture in the joints of tall stand-pipes increases faster than the thickness of metal to resist pressure alone. The additional thicknesses, to give joints the required strength, should also be included in the factor of safety.

According to J. T. Fanning, C.E., "the increase of factor of safety,  $f$ , may follow very nearly as the eleventh root of the fourth power of the depth, whence  $f = h^{\frac{4}{11}}$ ." This gives  $f = 2.97$  for a depth  $h = 20$  feet, and  $f = 6.87$  for  $h = 200$  feet.

The thickness required to resist water pressure alone in the upper portion of a stand-pipe is very small, and far below practical limits, since it is there that the greatest oxidation due to the alternate wetting and drying of the metal occurs, and in very cold weather strains due to ice expansion are produced. Consequently in practice, the upper sheets should not be less than  $\frac{3}{16}$  of an inch in thickness, with a stiffening angle at the top;  $\frac{1}{4}$ -inch iron is frequently used.

In the following table, which I have prepared to assist in proportioning the thickness of sheets, a minimum top thickness of  $\frac{3}{16}$  of an inch is assumed for diameters less than twenty-five feet, and  $\frac{1}{4}$ -inch for those greater than twenty-five feet. Sheets that will build four feet in height are often used, and this value has been assumed in the table.

ULTIMATE TENSILE STRENGTH OF IRON, 45,000 LBS. PER SQUARE INCH. HORIZONTAL SEAMS SINGLE, AND VERTICAL SEAMS BOTH SINGLE AND DOUBLE RIVETED.

Diameter. Feet.	U. S. Gallons per foot of depth.	Minimum thickness for the top.	Distance from the top to carry the min. thickn'ss	Distance from the top to carry single rivets.	Distance from the top of tank.	Constants to add to the min. thick- ness for each 4 ft. in depth below the distance given in 4th column. For tank ft. diam. Inches.
	Gallons.	Inches.	Feet.	Feet.	Feet.	
5	147.0	0.1875	64	40	24 28	0.00103 0.00109
6	211.7	0.1875	72	48	32 36	0.00114 0.00118
7	288.2	0.1875	76	48	40 44	0.00123 0.00127
8	376.4	0.1875	80	52	48 52	0.00131 0.00135
9	476.4	0.1875	72	48	56 60	0.00138 0.00142
10	588.7	0.1875	68	44	64 68	0.00145 0.00148
12	847.1	0.1875	60	40	72 76	0.00151 0.00154
12½	919.1	0.1875	56	36	80 84	0.00157 0.00159
15	1323.5	0.1875	48	32	88 92	0.00162 0.00165
16	1505.8	0.1875	48	32	96 100	0.00167 0.00169
18	1905.8	0.1875	44	28	104 108	0.00172 0.00174
20	2352.9	0.1875	40	24	112 116	0.00177 0.00179
22	2847.0	0.1875	36	24	120 124	0.00181 0.00183
25	3673.8	0.2500	40	28	128 132	0.00186 0.00187
27½	4448.5	0.2500	40	24	136 140	0.00189 0.00191
30	5294.1	0.2500	36	24	144 148	0.00193 0.00196
33	6405.8	0.2500	32	20	152 156	0.00197 0.00199
35	7205.8	0.2500	32	20	160 164	0.00201 0.00203
40	9411.7	0.2500	28	20	168 172	0.00204 0.00206
45	11911.7	0.2500	28	16	176 180	0.00207 0.00210
50	14705.8	0.2500	24	16	184 188	0.00211 0.00213
					192 196	0.00214 0.00217

The constants given in the right hand column of the table have been computed for a diameter of one foot, and are to be multiplied by the diameter of the given stand-pipe.

The limiting depths given in column four have been computed for exposed stand-pipes, in which the metal near the base is subject to wind pressure leverages. For enclosed stand-pipes of less than ten feet diameter, in order to obtain the most economical thickness of sheets, the limiting value of  $h$  should be determined in formula (B.) for the case in hand.

The details of any stand-pipe can now be readily tabulated, as follows:

DETAILS OF STAND-PIPE,  
20 FEET DIAMETER, 80 FEET HIGH.

Number of Sheet.	Distance from top of tank to bot- tom of each sheet. Feet.	Constants from table multiplied by 20.	Thickness of each sheet. Inches.	Capacity from top of tank to bottom of each sheet.	
				Gallons.	
1	4	0.0000	0.1875	9411.6	
2	8	0.0000	0.1875	18823.2	
3	12	0.0000	0.1875	28234.8	
4	16	0.0000	0.1875	37046.4	
5	20	0.0000	0.1875	47058.0	
6	24	0.0000	0.1875	56469.6	
7	28	0.0000	0.1875	65881.2	
8	32	0.0000	0.1875	75292.8	
9	36	0.0000	0.1875	84704.4	
10	40	0.0246	0.1875	94116.0	
11	44	0.0254	0.2121	103527.6	
12	48	0.0262	0.2375	112939.2	
13	52	0.0270	0.2637	122350.8	
14	56	0.0276	0.2907	131702.4	
15	60	0.0284	0.3183	141174.0	
16	64	0.0290	0.3467	150585.6	
17	68	0.0296	0.3757	159997.2	
18	72	0.0302	0.4053	169408.8	
19	76	0.0308	0.4355	178820.4	
20	80	0.0303	0.4663	188232.0	

The thickness given in decimals can easily be reduced to fractions of an inch, if desired.

Mild steel having an ultimate tensile strength greater than 45,000 lbs. per square inch, is often used for stand-pipes, and the constants to be employed in such a case may be found by multiplying each one in the right hand column of the table by the ratio  $\frac{45,000}{S_t}$ , when  $S_t$  is the ultimate tensile strength of the metal used.

However, as the relative corrosive effect of fresh water on mild steel and on iron has not been well determined, it is possible that the reduction in thickness due to the increased strength of the steel may be more than offset by the weakening effects of oxidation. The thickness for the bottom is taken equal to the thickness of sides at half height, by some engineers, but as it is subjected chiefly to compressive strains when properly supported by the foundation, it need be no thicker than can be thoroughly riveted and caulked.

A heavy angle iron should be placed around the outside of the stand-pipe, and double-riveted to both bottom and sides.

Stand-pipe foundations require a good class of masonry to resist the resultant thrust due to the combined effect of wind pressure and great weight of water.

C. J. PARKER.

ALUMNI NOTES.

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1871.

—J. N. Barr, M.E., has been appointed Superintendent of Motive Power of the Chicago, Milwaukee & St. Paul Railroad. He will also have charge of the Car Department, of which he has been superintendent for some time.

1876.

—Charles L. Taylor, E.M., has been appointed General Manager of the works of the Hartman Steel Company, Limited, at Beaver Falls, Pa.

1886.

—L. J. H. Grossart, C.E., has been appointed Instructor in Civil Engineering in Lehigh University.

1887.

—J. W. Kittrell, C.E., is at his home in Winona, Miss.

—S. D. Langdon, M.E., is with the Roane Iron Co., Chattanooga, Tenn.

—A. J. Wiechardt, M.E., is Professor of Mathematics at Adrian College, Adrian, Mich.

—O. O. Terrell, M.E., is foreman of the new Billet Mill, Pennsylvania Steel Co., Steelton, Pa.

—F. S. Smith, A.C., is in the employ of the Westinghouse Manufacturing Co., Pittsburgh, Pa.

—J. W. Scull, M. E., has gone into business for himself, and has extensive workshops in Philadelphia.

—M. D. Pratt, C.E., formerly with the Phoenix Bridge Co., is now employed by the Johnson Steel Street Rail Co., at Johnstown, Pa.

—E. T. Reisler, C.E., has been appointed Division Engineer on the Delaware Division of the New York, Lake Erie & Western Railroad. His address is Port Jervis, N. Y.

—J. C. Buckner, M.E., is at his home in Baltimore, Md. A poem in negro dialect, written by him, will shortly appear in *Harper's Monthly*.

—C. C. Jones, B.S., formerly Business Manager of the JOURNAL, is blast-furnace foreman at the Pennsylvania Steel Co.'s Works, at Steelton, Pa.

—J. A. Morrow, C.E., is with the American Water Supply Company, Pittsburgh, Pa. The water works at Coshocton, Ohio, the construction of which has been superintended by Mr. Morrow, are now completed.

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